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ACKNOWLEDGMENTS

The author wishes to thank Homer Cook, manager of the New Boston Food Market, Boston, Mass., for his assistance and personal interest in the study. The contributions made by officials of the Boston Gas Co. and Boston Edison Co. were extremely helpful in developing specific phases of the research.

AN EVALUATION OF GAS- AND ELECTRIC-POWERED CENTRAL REFRIGERATION SYSTEMS FOR FOOD DISTRIBUTION CENTERS

By Charles L. Goulston[1]

SUMMARY

This study compares the costs of owning and operating the natural-gas-powered refrigeration system at the New Boston Food Market, Boston, Mass., with a hypothetical electric-powered system. Results showed that the gas-powered system had higher initial cost but lower annual ownership and operating cost than the electric-powered system.

Differences in cost between the two systems were small. Initial costs were $692,100 for the gas and $662,100 for the electric system. Annual ownership and operating costs were $131,626 for the gas and $137,532 for the electric system. However, operating costs for the gas system are expected to decrease as management becomes more experienced in maintaining the system and as more capabilities of the equipment are realized.

In deciding between gas and electricity, one should consider many factors, such as initial, maintenance, and utility costs; insurance and tax rates; noise; and vibration. An intelligent decision cannot be reached until all factors have been considered.

INTRODUCTION

In 1968, the United States Department of Agriculture conducted a study[2] to determine the feasibility of providing refrigeration to a wholesale food distribution center by using central refrigeration rather than individual systems. The particular central system considered in that study used electrically powered compressors, and its capacity was approximately 580 tons of refrigeration[3]

In 1970, another study[4] was conducted under contract to the United States Department of Agriculture. As in the first study, the system considered used electrically powered compressors. However, the capacity of the Los Angeles system was approximately 7,300 tons of refrigeration, compared to 580 tons in the first study.

Both studies showed the economic advantages of central refrigeration as opposed to individual systems. In addition, other advantages were enumerated. For instance, an occupant of the distribution center would no longer have to raise capital to finance his own refrigeration system. A central plant also relieves the occupant of having to add more engine-room equipment as his refrigeration needs increase. Furthermore, it relieves him of any maintenance responsibilities.

The New Boston Food Market in Boston, Mass., opened in November 1969. One of the unique features of this market was that refrigeration was supplied by two central systems whose compressors were driven by natural-gas-powered internal combustion engines.

While the previously mentioned studies were concerned with evaluating central vs. individual systems

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[2]Stahlman, R. L. A study of refrigeration systems for urban food distribution centers. U. S. Dept. Agr., Mktg. Res. Rpt. 921. 1972.

[3]"Tons of refrigeration" is the measurement of the rate of heat extraction required to maintain room and product temperatures at desired levels. One ton of refrigeration equals 12,000 B.t.u.'s per hour.

[4]U.S. Agricultural Research Service. A master plan for a central refrigeration system for the proposed Los Angeles food distribution center. U.S. Dept. Agr., Agr. Res. Serv. ARS 52-27. 1970.

for both a medium and a very large distribution center, no study has been made of a natural-gas-powered "medium-sized" system such as that being used at the New Boston Food Market. For the purposes of this report, a medium-sized system is considered to be one having a capacity of 300 to 1,000 tons of refrigeration.

The purpose of this study is to compare the ownership and operating costs of one of the refrigeration systems at the New Boston Food Market with costs for a hypothetical, similar-sized, central electric-powered system and to determine which system is more economical. Of the two refrigeration systems at the market, this study confines itself to the one that serves the multiple-occupancy building.

Results of this study should assist interested personnel in determining which type of central refrigeration system, gas- or electric-powered, to install in a facility requiring 300 to 1,000 tons of refrigeration. Information contained herein could also be used to help project the costs of owning and operating central refrigeration systems larger than 1,000-tons capacity.

PROCEDURES USED TO DEVELOP COSTS

Capital expenditures related to the New Boston Food Market represent actual costs of the equipment, including labor and materials, at the time of purchase (1968). In some cases where actual costs were not available, estimates were made by the refrigeration contractor or the market manager.

Annual ownership and operating costs do not include insurance and taxes, because these items vary widely from one geographic area to another. Also, special concessions are often granted by governmental jurisdictions.

In amortizing capital expenditures, the "Equal Annual Payment" method[5] is used, set up in an annuity form so that the initial investment will be returned with interest compounded annually by the end of a given period. A 20-year amortization period is used in this study to reflect the expected life of the refrigeration equipment. A 6-percent interest rate was selected for use throughout this report simply to illustrate the application of interest costs. It may not reflect the actual interest rate that exists at a given time, nor does it reflect the actual interest rate being paid by the New Boston Food Market. It should also be noted that the amortization periods stated above do not reflect the period actually being used to amortize the New Boston Food Market.

Maintenance costs applicable to the Boston system are based on actual costs, and those applicable to the electric-powered system are based on estimates. These estimates were derived by using the actual costs mentioned above and adjusting them to reflect the differences in maintenance requirements for an electric system. See Appendix B for additional explanation.

Utility costs applicable to the Boston system are based on actual costs incurred during 1971. (See appendixes A, C, and D for details.) Electric costs applicable to the electric-powered system were derived by converting the amount of gas used in Boston to the equivalent amount of electricity that would be used by an electric system. See the section of this report entitled "Methods Used in Developing Electricity Costs for an Electric-Powered System" for additional explanation. Gas costs applicable to the electric system apply only to heating water. See "Calculation of Costs for Heating Water With and Without a Heat Recovery System" for additional explanation.

For the purposes of this study, it is assumed that room insulation costs would remain the same, regardless of which type system is used. Therefore, the only insulation costs considered will be for pipes and equipment. Also, the costs of equipment space will be ignored because of the many possible locations for refrigeration equipment and the variance in construction methods and costs.

THE NATURAL-GAS-POWERED CENTRAL REFRIGERATION SYSTEM AT THE NEW BOSTON FOOD MARKET

The New Boston Food Market (fig. 1) consists of one multiple-occupancy building that measures 920 by 132 feet, and seven single-occupancy buildings of various sizes. The multiple-occupancy building is served by a central refrigeration system located in an equipment room in the center of the building. The single-occupancy buildings are served by another central refrigeration system located in a separate equipment building (the latter system is not considered in this report).

[5]Baumeister, T. Mechanical engineers' handbook, 6th ed., p. 17-44. 1958.

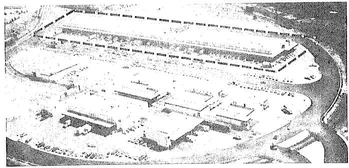

Figure 1.—The New Boston Food Market, Boston, Mass., (multiple-occupancy building enclosed in lines).

Description

Basically, the system consists of four ammonia compressors, each driven by a 225-hp., 1,200-r.p.m., natural gas engine. (See figs. 2 and 3.) Two booster compressors provide the additional compression necessary for the holding freezers. The term "holding freezers" is used, because prefrozen product is brought into this room at or near the temperature at which it will be held. In addition, third-stage booster compressors are located adjacent to the blast freezers in order to maintain the very low temperatures which are required. The blast freezers can be held at a temperature of about -35° F. They are designed to freeze product quickly through the use of rapidly circulating, low-temperature air. Ammonia flows from the equipment room to the various refrigerated rooms and back again through above-the-ground pipes.

The pressure differential between the refrigerant receiver and the evaporators causes the ammonia to flow to the evaporators at a controlled pressure of 75 p.s.i.

The system is capable of producing 500 tons of refrigeration. This is the theoretical capacity of the system. In reality, the system never runs at more than three-fourths of capacity. During the period March 23, 1971, to March 22, 1972, the four engines ran a total of 16,574 hours of a possible 35,040 hours. In other words, there is always at least one engine and compressor not running. This is a very desirable situation, because an engine and a compressor can be undergoing maintenance or can be on standby in the event of a malfunction of another engine or compressor.

The various refrigerated areas within the building have different refrigeration requirements, not only

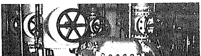

Figure 2.—Ammonia compressor.

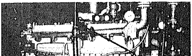

Figure 3.—Natural gas engine.

with regard to capacity, but also with regard to temperature. Three different operating-temperature ranges are required: -35° F for blast freezers, -10° F for holding freezers, and 35° to 45° F for coolers and workrooms. No air conditioning is supplied by this system. A summary of refrigerated spaces by temperature appears in table 1.

TABLE 1.—Summary of refrigerated space for the New Boston Food Market (multiple-occupancy building)

Description	Temperature (° F)	Square feet	Percent of total square feet
Workrooms	+45	27,400	34.6
Coolers	+35	43,100	54.5
Holding freezers	-10	8,300	10.5
Blast freezers	-35	300	0.4
Total		79,100	100.0

Costs

The cost of all the equipment used in this system, including that for labor and heat recovery, is $692,100. The total annual owning and operating costs ($131,626) for central refrigeration system (gas-powered) are shown as follows:

	Total cost
Amortization, capital cost (20 yr. @ 6% – $692,100 x 0.08718)	$60,337
Maintenance[1]	33,600
Gas power cost[2]	20,728
Electric power cost[3]	16,961
Total annual owning and operating costs	$131,626

[1] See appendix B.

[2] This is based on actual usage in 1971. It includes the cost of gas used to heat water when the amount of heat recovered from the engines is insufficient. See appendixes A and C for additional explanation.

[3] This is based on actual usage in 1971. Even though the system is primarily gas driven, electricity is used to operate the controls, pumps, booster compressors, etc. See appendixes A and D for additional explanation.

The above data are based on costs that occurred in 1971, which was the second full year of operation. It is important to note that maintenance and utility costs should decrease as management becomes more experienced in maintaining the refrigeration system and as tenants are educated in the proper management of their refrigerated spaces. For example, tenants should not leave doors open longer than necessary; lights should be turned off whenever possible; and refrigeration should be turned off during cleanup.

Significant savings in maintenance and utility costs have already been realized during the first 3 years of operation. In addition, management is attempting to reduce utility costs further by using more capabilities of the gas system. For example, they are considering heating offices with waste steam from the boiler, rather than condensing the steam into water; also, using standby gas engines to generate electricity to light the yard and to provide power for water pumps and fans.

The Heat Recovery System

While discussing the gas-powered system, it is important to call attention to the unique heat recovery system that is, in essence, a part of the refrigeration system. The heat recovery system is designed to recover heat from the engine exhausts and from the engine-cooling jackets and to convert it to steam that, in turn, is used to make hot water. When there is insufficient heat recovered from the engines to meet the demand for hot water, then a boiler that runs on natural gas fires up to make up the difference. Heat recovery would not be feasible with an electric system, since very little heat is generated by electric motors in comparison with gas engines.

If there were no heat recovery equipment, then the boiler would furnish all of the necessary heat by firing up more often. Not only would this use more gas, but the unit cost of gas would be considerably greater than at present. The reason for this is that the low gas rates that now apply to the refrigeration system would no longer apply to the boiler as well, because the Boston Gas Company, which supplies the gas, would no longer consider the boiler a part of the refrigeration system. The boiler would then have to be placed on a separate gas meter, and the cost of a cubic foot of gas would approximately double because of the relatively small amount of gas being used by the boiler.

The actual cost of the heat recovery equipment was $37,000, including labor. However, if this equipment were omitted, it would have been necessary to spend approximately $27,000 to purchase alternate equipment to perform some functions, such as engine cooling, which are presently being done by the heat recovery equipment. As a result, we can say that the effective cost of this equipment is $37,000 - $27,000 = $10,000, rather than $37,000.

The savings accrued through the recovery of heat are estimated to be $4,449 per year. A detailed explanation of the savings follows.

Calculation of Costs for Heating Water With and Without a Heat Recovery System

The following calculations are based on the use of 52,000 gallons of hot water per week, 45,000 gallons of which are heated at virtually no cost by the heat recovered from the engines. Some assumptions are: The temperature of the water is raised 100 degrees Fahrenheit; 1,000 B.t.u. of heat are obtainable from a cubic foot of gas; and the boiler is 80 percent efficient. The cost of gas is $0.90/ m.c.f., an m.c.f. being 1,000 cubic feet of gas. If the hot water system were not connected to the refrigeration system, this cost would be $1.70/ m.c.f.

a. If there were no heat recovery system, the cost of gas required to heat 52,000 gallons of water would be calculated as follows:

$$\frac{\frac{52{,}000 \text{ gal.}}{\text{week}} \times \frac{8.34 \text{ lb.}}{\text{gal.}} \times 100 \text{ degrees} \times \frac{1 \text{ B.t.u.}}{\text{lb.-degree}} \times \frac{1 \text{ cu. ft.}}{1{,}000 \text{ B.t.u.}}}{80 \text{ percent efficiency}}$$

$= 54.2$ m.c.f./week.

54.2 m.c.f. x $1.70/m.c.f. = $92.14/week = $4,791/year.

b. If 45,000 gallons of water were heated by the heat recovery system each week, then the remaining 7,000 gallons must be heated by firing the boiler. The cost of gas necessary to accomplish this is calculated as follows:

$$\frac{\frac{7{,}000 \text{ gal.}}{\text{week}} \times \frac{8.34 \text{ lb.}}{\text{gal.}} \times 100 \text{ degrees} \times \frac{1 \text{ B.t.u.}}{\text{lb.-degree}} \times \frac{1 \text{ cu. ft.}}{1{,}000 \text{ B.t.u.}}}{80 \text{ percent efficiency}}$$

$= 7.3$ m.c.f./week.

7.3 m.c.f. x $0.90/m.c.f. = $6.57/week = $342/year.

c. The gas savings that result from the heat recovery system are: $4,791 - 342 = $4,449/year.

Method for Charging Users for Refrigeration

At the New Boston Food Market, tenants are not charged separately for the refrigeration they use. Refrigeration charges are included in each tenant's monthly "rent" and do not vary with the amount of refrigeration that he actually uses. The term "rent" is used only for convenience. Since each tenant is a shareholder in the New Boston Food Market Development Corporation, the term actually refers to the tenant's monthly share of the ownership and operating costs. This monthly rent is determined by allocating operating expenses and debt amortization costs to each tenant on the basis of the actual construction cost for the space that he occupies as a percentage of the construction cost of the entire market. Since operating costs vary periodically, the rents are adjusted annually.

Although this method of charging appears to be working quite well, a more satisfactory method would be based on (1) a flat charge for each evaporator and (2) the amount of refrigeration used, with a different rate applied to each category of suction temperature. To determine the amount of refrigeration used, a meter would be installed on each liquid refrigerant mainline. The meter would be read monthly, and tenants would be billed accordingly.

AN ELECTRIC-POWERED CENTRAL REFRIGERATION SYSTEM

For purposes of comparison, the electric-powered refrigeration system described below was hypothesized in order to arrive at a system that would be equivalent to the gas system used in Boston.

Description

An electric-powered system would be nearly identical to the gas-powered one, the main exception being that the compressors would be driven by electric motors instead of gas engines. Consequently, there would be no requirement for cooling the engines and, therefore, no heat could be recovered to make hot water. The capacity of this system would still be 500 tons of refrigeration, because cooling requirements would be the same for both systems (table 1).

Costs

The cost of all equipment used in this system is $662,100. This includes the costs of all labor and the installation of additional electric service for the

motors. The total annual owning and operating costs ($137,532) for central refrigeration system (electric-powered) are shown as follows:

	Total cost
Amortization, capital cost	
(20 yr. @6% – $662,100 x 0.08718)=	$57,772
Maintenance[1]	27,000
Electric power cost[2]	47,969
Gas cost[3]	4,791
Total annual owning and operating costs .	$137,532

[1] See appendix B.

[2] See next section for explanation.

[3] This would be the cost of gas to make hot water. See "Calculation of Costs for Heating Water With and Without a Heat Recovery System" for explanation.

Methods Used in Developing Electricity Costs for an Electric-Powered System

To determine owning and operating costs for an electric-powered central refrigeration system, we must determine the cost of electricity to run the motors that drive the compressors. However, it is first necessary to determine the amount of electricity that would be used for this purpose.

Since we know the relative efficiencies of the gas engines and equivalent electric motors, and also the heat content of a cubic foot of gas and a kilowatt-hour of electricity, we can readily convert one to the other. It was determined that 11.0 cubic feet of gas is equivalent to approximately 1 kilowatt-hour of electricity.

Since our records showed that 19,860,000 cubic feet of gas were used to drive the compressors in 1971, which does not include gas used to make hot water, we can convert this to kilowatt-hours by dividing by 11.0, which gives us 1,805,000 kw. -hr. of electricity. From this figure, and from rates supplied by the Boston Edison Company (using wholesale power rate G), we determined that electricity to drive the compressors would cost an additional $31,008 per year. Adding to this the cost of electricity now being used by the refrigeration system, $16,961 per year (see p. 4), we arrive at a new electric power cost of $47,969 per year.

COST COMPARISON BETWEEN A GAS- AND AN ELECTRIC-POWERED CENTRAL REFRIGERATION SYSTEM

Table 2 shows costs for the gas-powered system at the New Boston Food Market compared with costs for the electric-powered system. The gas system costs more to install but less to own and operate than the electric system. However, the differences in costs are small, and it should be obvious that, depending on the particular situation, either system may prove more advantageous than the other.

TABLE 2.–Cost comparison: gas vs. electric system

Type of cost	Gas system	Electric system
	Dollars	*Dollars*
Initial	692,100	662,100
Per ton refrigeration	1,384	1,324
Per square foot[1]	8.75	8.37
Annual owning and operating	131,626	137,532
Per ton refrigeration	263	275
Per square foot[1]	1.66	1.74

[1] Based on refrigerated space only.

FACTORS TO BE CONSIDERED IN CHOOSING A CENTRAL REFRIGERATION SYSTEM

In deciding between a gas- and an electric-powered central refrigeration system, the following factors must be considered:

- Initial cost will vary with such factors as the size of the system, desired operating temperatures, number and size of evaporators, and type of refrigerant.
- Insurance rates and tax rates vary considerably from one location to another. Lower insurance rates are usually available when the coverage is included in a larger package that covers the entire facility. Special tax concessions are often granted by local governmental jurisdictions.
- Utility costs also vary considerably. One utility company may be willing to offer special concessions that the other company cannot offer. In some instances, it may be advisable to switch from one fuel to another in order to benefit from seasonal rate fluctuations. When determining utility costs, one should consider the possibility of future rate changes, as well as present rates. The utility having the lower present cost could turn out to be more expensive in the long run because of future rate increases.
- Maintenance is much more critical for the gas system than for the electric system, since the former requires more attention. Also, few people are capable of maintaining gas engin than they are electric motors. Whether the mai tenance of a gas system is in-house or on co tract is determined by the availability of pro erly trained mechanics. Type and frequency maintenance greatly affects the life of a g engine.
- Good management is more essential to t success of a gas system than to the success of a electric one. The experienced manager kno when to schedule periodic maintenance and ho to get the best performance and optimum u from his engines. He also knows where to b parts and lubricants at lowest cost, there keeping expenses at a minimum.
- Because of the nature of gas engines, th system is noisier and causes more vibration tha the electric system does. Every effort should b made to isolate the gas engines so that they w not cause discomfort to anyone.
- A heat recovery system can be connected most gas refrigeration systems. However, it m not always be a worthwhile investment. T determine its feasibility, consider equipment a local utility costs, as well as requirements f heat recovered from the engines.

APPENDIX A

TABLE 3.–Cost of utilities for refrigeration, New Boston Food Market, 1971 (multiple-occupancy building)

Month	Gas[1]		Electricity[3]	
	Gas used	Cost of gas[2]	Electricity used	Cost of electricity
	C.c.f.[4]	*Dollars*	*Kw.-hr.*	*Dollars*
Jan.	11,000	1,634	63,443	1,345
Feb.	14,400	1,628	63,302	1,342
Mar.	12,000	1,537	61,651	1,344
Apr.	16,600	1,875	65,467	1,401
May	16,100	1,595	60,742	1,391
June	18,400	1,696	79,202	1,687
July	17,400	1,636	72,081	1,593
Aug.	18,000	1,658	76,396	1,696
Sept.	19,500	1,753	64,105	1,468
Oct.[5]	21,500	1,951	54,403	1,322
Nov.[5]	20,400	1,905	50,976	1,230
Dec.[5]	17,100	1,860	44,064	1,142
Total	202,400	20,728	755,832	16,961

[1] Figures that appear under this heading include gas used for heating water.

[2] Figures in this column have been adjusted to nullify the effect of lower rates that result from having two gas refrigeration systems in the market.

[3] Figures that appear under this heading have been adjusted to include only costs that relate to the refrigeration system. Some excluded items are costs to air-condition the restaurant (separate air-conditioners were purchased for this purpose) and lighting costs.

[4] "C.c.f." means 100 cubic feet.

[5] During the months of October, November, and December, the booster compressors were run by gas engines instead of by electric motors. The market management wished to determine the effect of such a change on their utility costs. This explains the abnormally high gas costs and low electric costs during this period.

APPENDIX B

Notes on Maintenanca Costs

Most maintenance work, routine and otherwise, is done in-house by personnel of the New Boston Food Market. Occasionally, an outside contractor is summoned to handle a major repair. The annual maintenance cost of $33,600 shown on page 4 is based on actual costs. It includes labor, part-time use of a truck, costs of outside contractors, parts, supplies, and the premium for major-breakdown insurance.

If this system were electrically powered, estimated maintenance costs would be $27,000 (page 6). The reason for this lower figure is mainly due to the decreased maintenance requirements of electric motors as compared with gas-powered engines.

The estimated costs of a complete maintenance contract for the Boston system, which would include periodic inspections, preventive maintenance, oil, refrigerant, replacement parts, labor, and 24-hour emergency service, would be $66,000 per year.[6] In addition, the owner would still need one man present during the day to monitor the system and to make minor adjustments and repairs. By comparison, the cost of maintaining an electric system entirely on a contract basis is estimated at $50,000 per year,[6] plus the cost of one man on the premises during the day.

In conclusion, the owner of either type system should consider performing his own maintenance rather than having it done on contract; however, the owner of the gas system would probably save more money than the owner of the electric system by doing this. In any event, this is a decision that would have to be made locally, since it would depend on local labor rates and maintenance contract prices as well as on the availability of skilled labor.

[6]This figure was supplied by a refrigeration contractor.

APPENDIX C

BOSTON GAS COMPANY

BOSTON DIVISION

OPTIONAL DEMAND RATE

CLASSIFICATION NO. 14

Availability: Available to any non-residential customer for gas used for prime movers, and/or for boilers for steam and/or hot water generation; for firm gas supplied at a single point of delivery provided (1) that the Company's distribution system has adequate capacity to supply the customer's requirements and (2) that the customer has executed a service agreement with the Company setting forth the specific terms for application of this rate.

Character of Service: Natural gas containing not less than 1,000 BTU per cubic foot.

Rate:

Demand Charge (Based on Billing Demand)

First	20,000 cubic feet or less	$158.00 per month
Next	30,000 cubic feet	0.77 per month per 100 cu. ft.
Over	50,000 cubic feet	0.71 per month per 100 cu. ft.

PLUS

Commodity Charge

First	250,000 cubic feet per month . . .	$0.051 per 100 cu. ft.
Next	500,000 cubic feet per month . . .	0.046 per 100 cu. ft.
Over	750,000 cubic feet per month . . .	0.041 per 100 cu. ft.

Discount: Two (2) per cent

Provided bill is paid in full, including all arrears, within 15 days from billing date.

Minimum Monthly Charge: The minimum monthly charge shall be the demand charge plus the commodity charge for 18 days use of the billing demand.

Price Adjustment: As provided on M.D.P.U. No. 381, except that any adjustment in the rate for gas, contained herein above, made by the Company resulting from a change in the wholesale price of natural gas shall be an amount equal to the increase or decrease of the demand and/or commodity cost of firm gas purchased by the Company from the demand and commodity cost of such gas to the Company as of December 1, 1966.

Issued - January 14, 1972

(Continued on Page 14-A)

Effective - January 14, 1972

Issued by W. J. Pruyn, President
2900 Prudential Tower, Boston

OPTIONAL DEMAND RATE (CONTINUED)

CLASSIFICATION NO. 14

Determination of Billing Demand:

The billing demand for any month shall be equal to the largest of: (1) for any peak period month (November 1 through March 31) the highest daily demand recorded during the period, or (2) for any off-peak month (April 1 through October 31) one-third (1/3) of the highest daily demand recorded during the period, or (3) the highest daily demand in any peak period month (November 1 through March 31) within the preceding 11 months.

In the case of a customer who first uses gas during the April through October period, the billing demand for all months prior to the following November shall be that agreed upon by the Company and the customer.

Terms and Conditions of Gas Service: As provided on M.D.P.U. No. 380.

Resale: This rate is not available for the purchase of gas for resale.

Boston Edison Company
800 Boylston Street, Boston

Sheet No. 2

M.D.P.U. No. 187
Cancels M.D.P.U. No. 169

WHOLESALE POWER RATE G — (Continued)

Primary or High-Tension Credit: Where only alternating current service is supplied a credit of two per cent of the total bill not including Miscellaneous Charges and before deduction of the Transformer Ownership Allowance, will be made when energy is metered at the nominal voltage of 2400 volts or higher.

Transformer Ownership Allowance: Where only alternating current service is supplied and where a customer furnishes, installs, owns and maintains at his expense all the protective devices, transformers, and other equipment required, as specified by the Company*, the electricity so supplied will be metered by the Company at line voltage and the monthly demand charges will be reduced as follows:

a. 10 cents per kilowatt of demand when the demand is 75 kilowatts or more and the nominal voltage is 2400 volts single phase or 4160 volts three phase, or

b. 30 cents per kilowatt of demand when the demand is 150 kilowatts or more and the nominal voltage is 6900 volts or 13,800 volts.

*The Company will specify the equipment required upon request.

Maximum Rate and Minimum Charge: If the service is not auxiliary to other sources of power, and a customer's net bill for any month exceeds the amount it would have been if computed at 5.9 cents per kilowatthour, a credit will be made of such excess amount provided the bill shall in no case be less than $142.00.

Term of Contract: No term contract required; customer may terminate service at any time by giving ten days' notice in writing, provided that such termination is not made for the purpose of obtaining the advantage of this rate for periods of less than one year.

Auxiliary Service Charge, Emergency Service Charge and Welding Machine Charge as respectively provided from time to time in schedule of Miscellaneous Charges.

Terms and Conditions, severally in effect from time to time, as provided in schedule of Terms and Conditions.

WHOLESALE POWER RATE G

.vailable for heating and power uses including lighting, incidental to the foregoing, on the premises specified in the agreement for service. This rate is not available where any portion of the energy is resold or is used for domestic service in residential premises.

ate:

Demand Charge

$142.00 per month for the first 50 kilowatts of demand or any portion thereof.
2.35 per kilowatt per month for the next 250 kilowatts of demand.
2.15 per kilowatt per month for the next 500 kilowatts of demand.
2.00 per kilowatt per month for the next 2200 kilowatts of demand.
1.80 per kilowatt per month for the excess.

Energy Charge

2.75 cents per kilowatthour for the first	4,000 kilowatthours per month.
1.60 cents per kilowatthour for the next	16,000 kilowatthours per month.
1.20 cents per kilowatthour for the next	100,000 kilowatthours per month.
0.97 cent per kilowatthour for the excess over the excess over	120,000 kilowatthours per month; except that for

(a) 120,000 kilowatthours per month when the demand is less than 400 kilowatts, or
(b) 300 hours' use of the demand per month when the demand is 400 or more kilowatts, the energy charge shall be

0.72 cent per kilowatthour.

Additional Energy Charge

0.5 cent per kilowatthour for all direct current energy.

Fuel Adjustment as provided in "Fuel Clause No. 1", applicable to all kilowatthours on this rate.

etermination of Demand: The maximum thirty-minute demand (either kilowatts or 80 per cent of the kilovolt-amperes) will be determined by meter during the monthly billing period. The number of kilowatts of demand billed shall be the demand so determined, but in no case less than the highest of the following: (1) 50 kilowatts; (2) two and one-half times the connected lighting load excluding lighting in manufacturing areas of the premises specified in the agreement for service and (3) where Auxiliary Service is supplied, the Auxiliary Service Capacity. Demands established prior to the application of this rate shall be considered as having been established under this rate.

lectric Furnace Load: Available for alternating current service to electric furnace loads with a demand of not less than 200 kilowatts. Not available for Auxiliary Service.

Provided electricity is separately metered and is not furnished under this rate during certain hours specified from time to time by the Company, but not exceeding 500 hours in a year, or 4 hours in any day, the demand shall be reduced by 50 per cent for the purpose of determining the demand charge, and the energy charge shall be 0.97 cent per kilowatthour.

(Continued)

FUEL CLAUSE NO. 1

FUEL ADJUSTMENT: Whenever in any month the cost of fossil fuels priced alongside the Company's electric generating stations is greater than $8.20 or less than $8.05 per ton of 29,000,000 British thermal units, an additional charge or deduction will be applied to the kilowatthours which are billed in the second succeeding billing month.

This charge or deduction will be determined by multiplying the increase of each full cent above $8.20 or the decrease of each full cent below $8.05 by 0.00039 and by the ratio of kilowatthours generated by fossil fuels to total kilowatthours generated and purchased in that month.

In determining the cost of fossil fuel used in any month, the cost of the fossil fuel received during the month will be averaged with the cost of fossil fuel in storage at the beginning of the month.